Nissen
(missed meeting)
9/16/91

INTERMOUNTAIN POWER PROJECT

BURNER UPGRADE REVIEW

RJM CORPORATION

all SS 309

petal-shaped backplate
vs donut-shaped

SEPTEMBER 13, 1991

~~Raffa~~ SLC

R Monroe

IPSC Jerry
Jim
Cecil

Don Langley
Byron F.

THE RECOMMENDED BURNER DESIGN MODIFICATIONS AND MATERIAL SELECTIONS ARE BEING PROVIDED BY THE RJM CORPORATION, WITH THE UNDERSTANDING THAT THE FINAL DESIGN DECISION AND IMPLEMENTATION SHALL BE THE RESPONSIBILITY OF THE INTERMOUNTAIN POWER SERVICE CORPORATION AND THE BABCOCK AND WILCOX COMPANY.

IPP.DIS

INTERMOUNTAIN POWER PROJECT
RECOMMENDED MATERIALS

(BASED ON SLIP FIT/SEGMENTED PANEL BACK PLATE AND SLIP FIT FRONT PLATE)

COMPONENT	MATERIAL
REGISTER FRONT PLATE	1/2" A36 PLATE *
REGISTER BACK PLATE	1/2" TP304H PLATE *
INNER AIR SLEEVE	1/4" TP309H PLATE *
THROAT SLEEVE	1/4" TP304H PLATE *
SLIP SEAL CASING	3/16" TP304H PLATE *
COAL PIPE TIP	1/2" TP309H PLATE *

(* - DENOTES MATERIAL AS IS CURRENTLY INSTALLED)

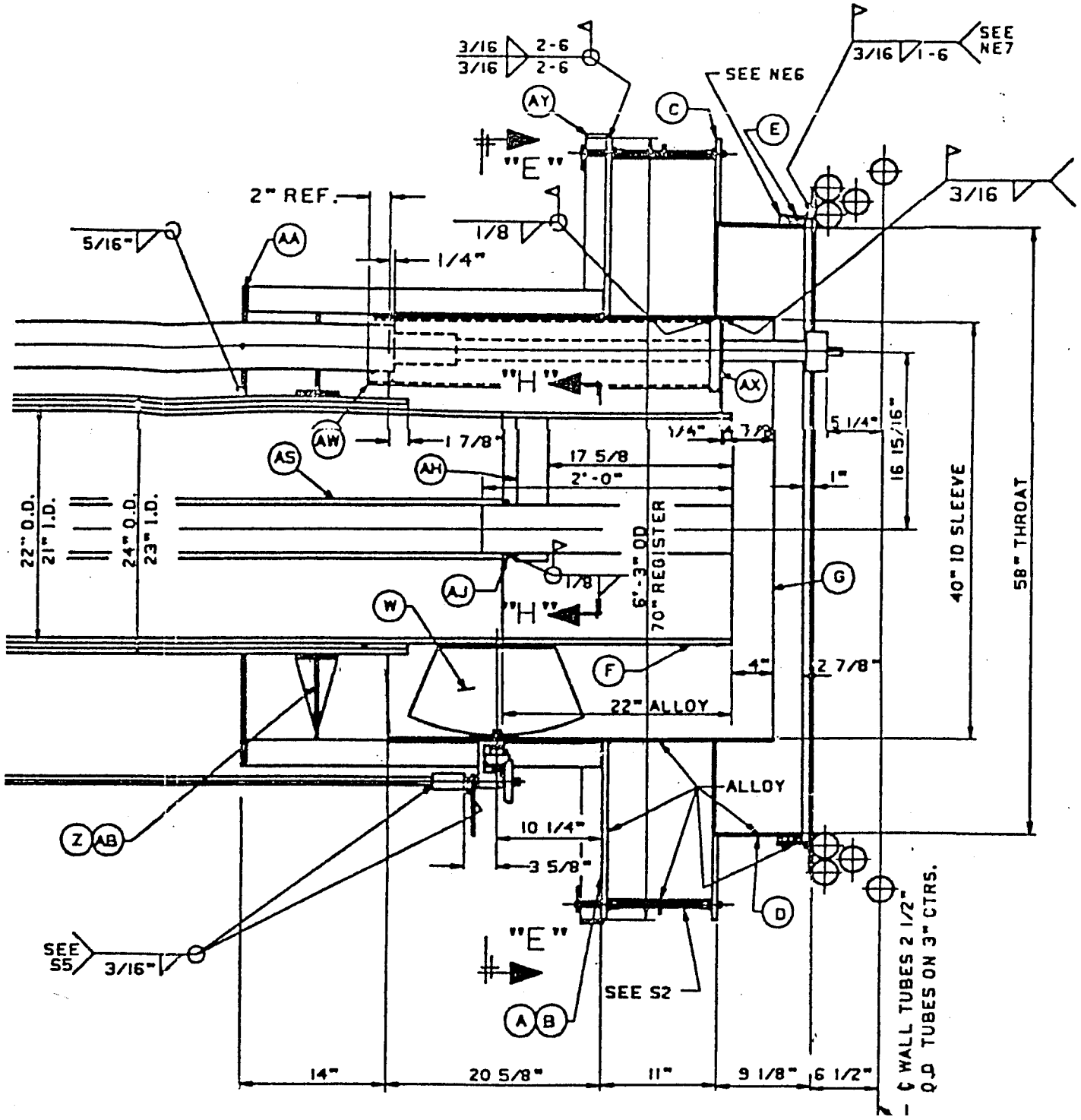
IPP.RM

INTERMOUNTAIN POWER PROJECT

SLIP FIT REGISTER
DETAIL DESIGNS

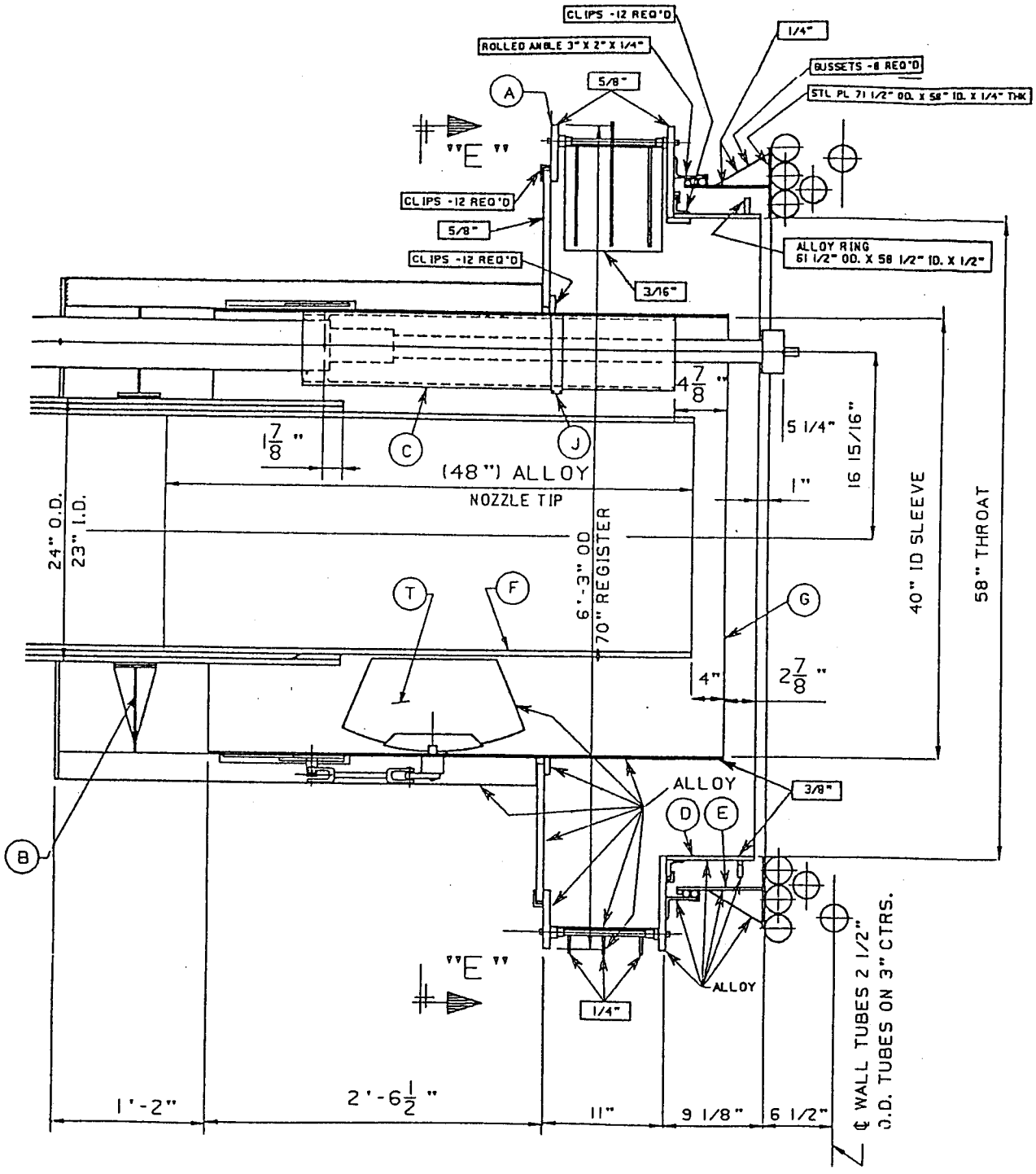
- SLIP FIT CLIPS
- NUMBER OF SEGMENTED BACK PLATE PANELS (ESTIMATED 4-6 REQUIRED)
- MEANS TO HOLD RADIAL AND AXIAL POSITIONS OF REGISTER END PLATES
- RADIAL POSITIONING OF THROAT SLEEVE

IPP.SFR


3/16 2-6
3/16 2-6
SEE NE6
3/16 1-6
SEE NE7
AY
C
E
"E"
2" REF.
1/8
3/16
5/16"
AA
1/4"
"H"
AX
AW
1 7/8"
1/4"
7/8
5 1/4"
16 15/16"
AS
AH
17 5/8
2'-0"
1"
22" O.D.
21" I.D.
24" O.D.
23" I.D.
6'-3" OD
70" REGISTER
40" ID SLEEVE
58" THROAT
AJ
1/8
"H"
G
W
F
4"
2 7/8"
22" ALLOY
ALLOY
Z
AB
10 1/4"
3 5/8"
D
SEE S5
3/16"
"E"
SEE S2
A
B
14"
20 5/8"
11"
9 1/8"
6 1/2"
℄ WALL TUBES 2 1/2" O.D. TUBES ON 3" CTRS.

IP7_003253

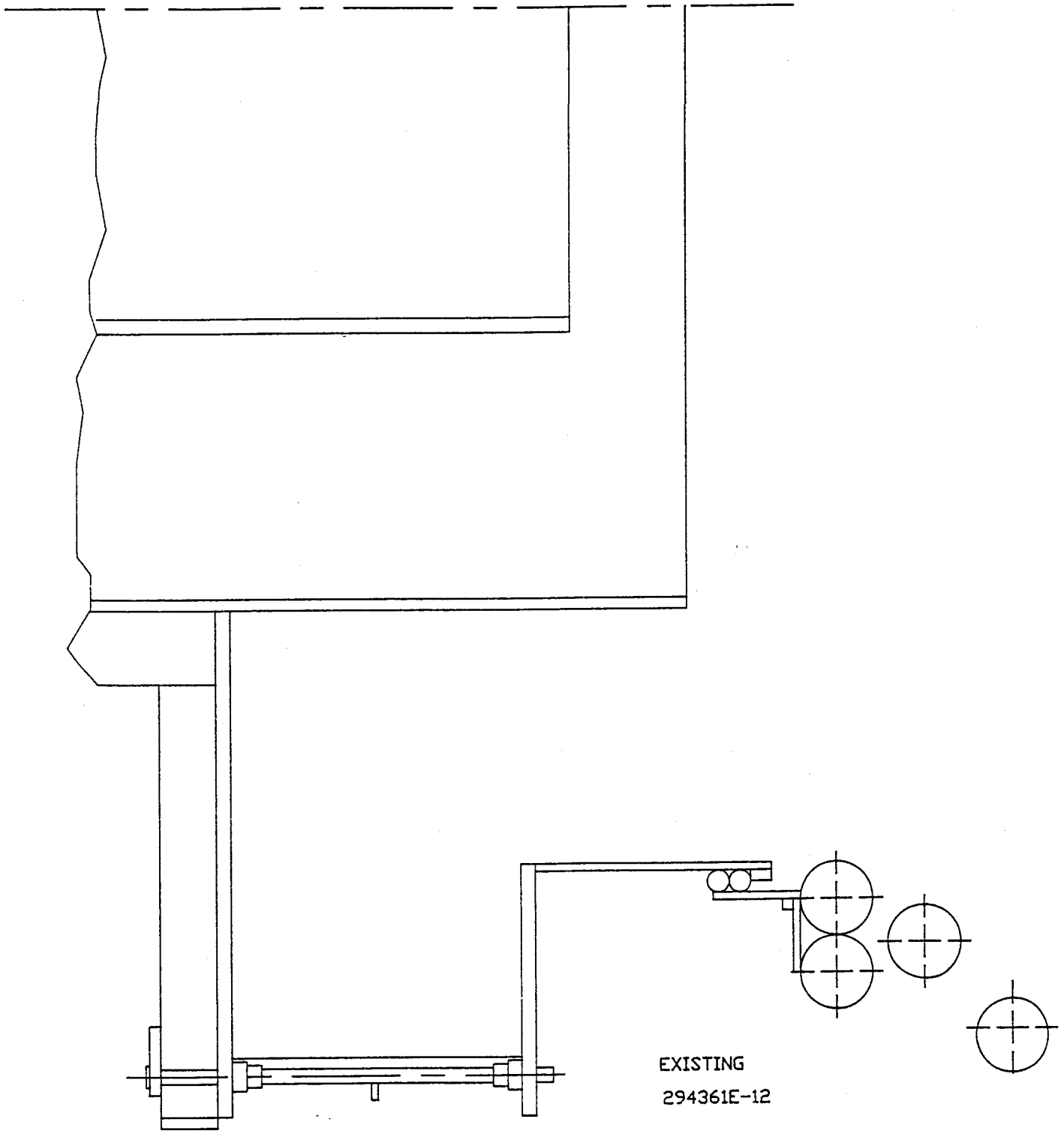
INTERMOUNTAIN POWER PROJECT - PROPOSED DESIGN (REF. SK4179[illegible]-0)



IP7_003254

INTERMOUNTAIN POWER PROJECT

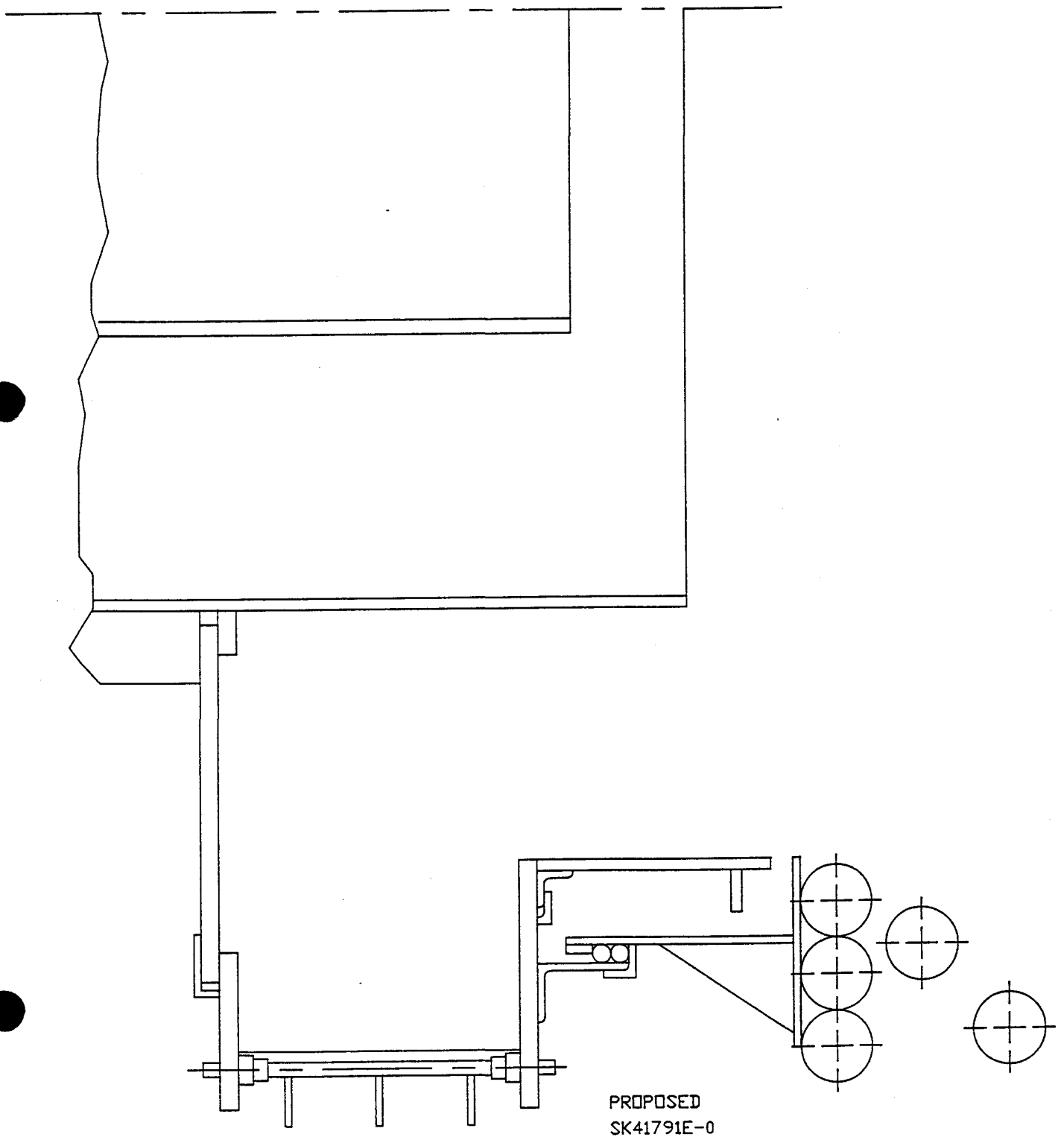
EXISTING DESIGN
(REF. 294361E-12)



INTERMOUNTAIN POWER PROJECT

PROPOSED DESIGN

(REF. SK41791E-0)



EXISTING DESIGN PROBLEMS

COAL PIPE

- NOZZLE TIP BURNING/WARPING

INNER REGISTER

- SLEEVE WARPING
- REGISTER VANE JAMMING

OUTER REGISTER

- BACK PLATE WARPING
- THROAT INTERACTION WITH AIR SEAL
- REGISTER VANE JAMMING

IPP.EDP

BURNER - UNIT 2

(REF. RB-0615 - NOVEMBER 24, 1988)

BURNER MODIFICATIONS

- EXPANSION JOINTS WERE INSTALLED ON THE OUTER REGISTER DRIVE HANDLES
- BACKPLATES AMD FRONT PLATES OF REGISTERS WERE CUT FREE AND EXPANSION CLIPS WERE INSTALLED

BURNER SETTINGS

- OUTER REGISTERS - 6" (DOOR STIFFENER TO DOOR - ON A PERPENDICULAR)
- SPIN VANES - 30° (WHERE 90° IS STRAIGHT THROUGH, 0° IS CLOSED)
- BACK PLATES - 5", 4", 3", 3", 4", 5" OPEN
- (ALL BURNER SETTINGS HAVE BEEN LOCKED IN PLACE)

IPP.BS

BURNER UPGRADES
PROPOSED MODIFICATIONS SK41791E/0

(REF. RB-614/615 - MAY 1, 1991)

OUTER AIR REGISTER

- o REPLACED WITH MODIFIED HD REGISTER
- o REGISTER FRONT PLATE
  - THICKNESS FROM 1/2" TO 5/8"
  - MATERIAL FROM CARBON STEEL TO 800H
- o REGISTER BACK PLATE
  - THICKNESS FROM 1/2" TO 5/8"
  - MATERIAL FROM TP304 TO 800H
  - SUPPORT LEGS ADDED
  - CENTER SECTION ATTACHED TO FRAME WITH CLIPS (PROVIDES FOR EXPANSION)
- o REGISTER DOOR
  - THICKNESS FROM 10 GA. TO 3/16"
  - ALLOY STIFFENERS ADDED

THROAT SLEEVE

- o THICKNESS FROM 1/4" TO 3/8"
- o MATERIAL FROM TP304 TO 800H
- o EXPANSION RING ADDED TO OD
- o ATTACHED TO FRONT PLATE WITH CLIPS (PROVIDES FOR RADIAL EXPANSION)

BURNER UPGRADES
PROPOSED MODIFICATIONS SK41791E/0

(REF. RB-614/615 - MAY 1, 1991)

(CONTINUED)

SLIP SEAL

- MOVED OUTBOARD ON FRONT PLATE TO ELIMINATE INTERFERENCE WITH EXPANSION OF THROAT SLEEVE
- SEAL REARRANGED TO MINIMIZE RADIANT HEAT ON ROPE PACKING

INNER AIR SLEEVE

- THICKNESS FROM 1/4" TO 3/8"
- MATERIAL FROM TP309 TO 800H
- MATERIAL OF STIFFENERS FROM CARBON STEEL TO 800H
- SPIN VANE DRIVE OPERATION CHANGED FROM GEARED TO PUSH/PULL
- INNER SLEEVE LENGTH INCREASED APPROXIMATELY 10"

COAL NOZZLE

- ALLOY PORTION OF TIP FROM 33" TO 48"

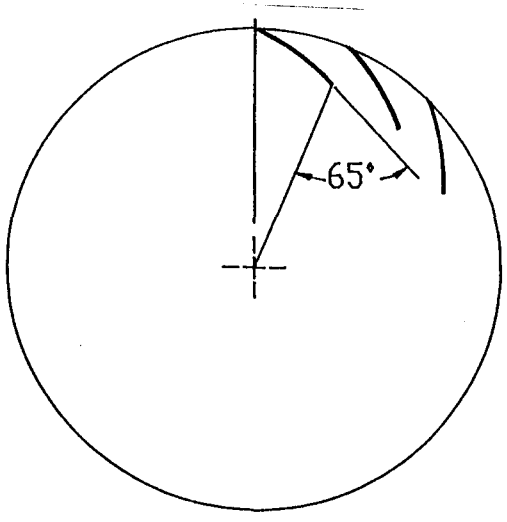
IPP-BU

AERODYNAMIC ANALYSIS

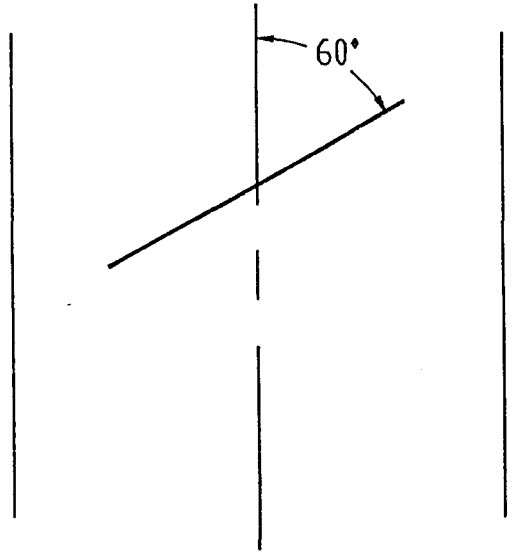
IPP.AA

AIR REGISTERS

- OPERATING CONDITIONS
  - 100 PERCENT LOAD WITH 42 BURNERS
  - AIR TEMPERATURE = 650°F
  - WINDBOX TO FURNACE DIFFERENTIAL PRESSURE = 2.0 INCHES WATER
- SETTINGS (REF. NOVEMBER 24, 1988)



OUTER REGISTER VANE
EXIT FLOW ANGLE (OFF RADIAL)



INNER SPIN VANE
EXIT FLOW ANGLE (OFF AXIAL)

IPP.AR

REGISTER AERODYNAMIC SUMMARY/RESULTS

- OUTER REGISTER (PER BURNER)

  increase
  55% → 65%

  - AIR FLOW = 19.1 LBM/SECOND
  - INTEGRATED SWIRL NUMBER = 1.639
  - RECIRCULATION PARAMETER (AT HUB) = -0.2 INCH WATER

- INNER REGISTER (PER BURNER)

  45% → 35%
  by spin vanes

  - AIR FLOW = 15.2 LBM/SECOND
  - INTEGRATED SWIRL NUMBER = 1.356
  - RECIRCULATION PARAMETER (AT HUB) = -0.4 INCH WATER

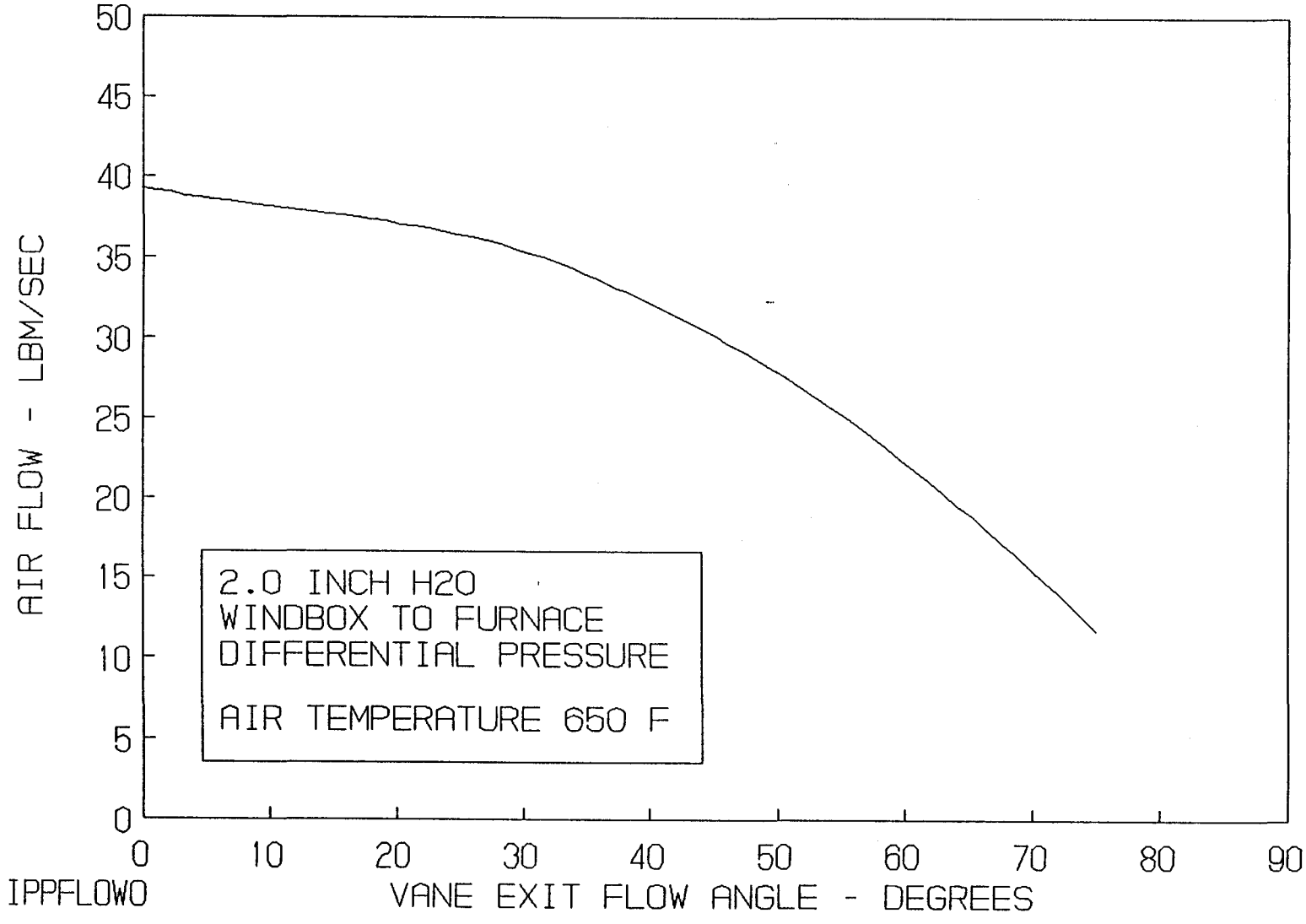
B&W concerns
flames walking away

IPP.RAS

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN

AIR FLOW

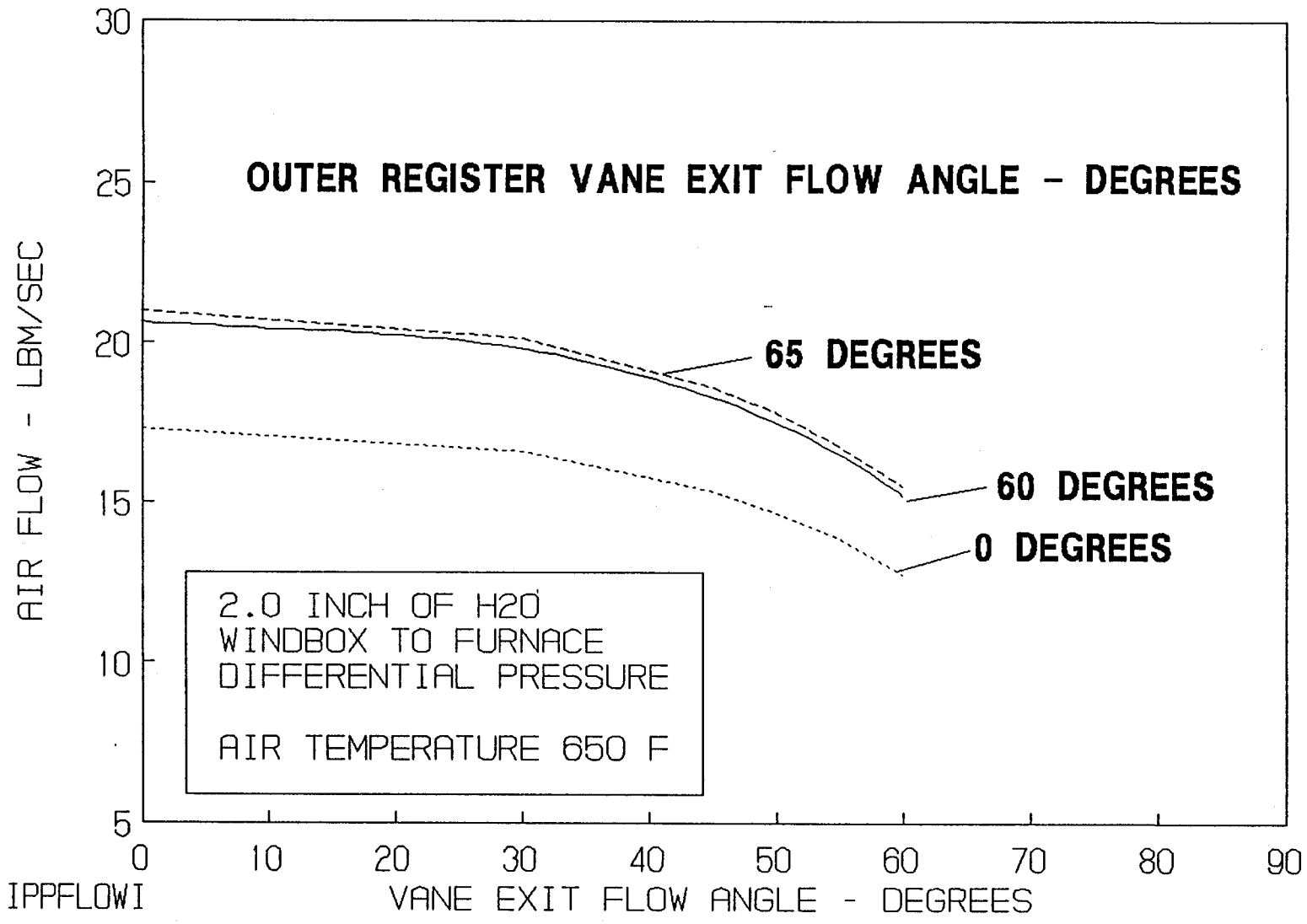


IP7_003264

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

INNER AIR REGISTER - EXISTING DESIGN

AIR FLOW

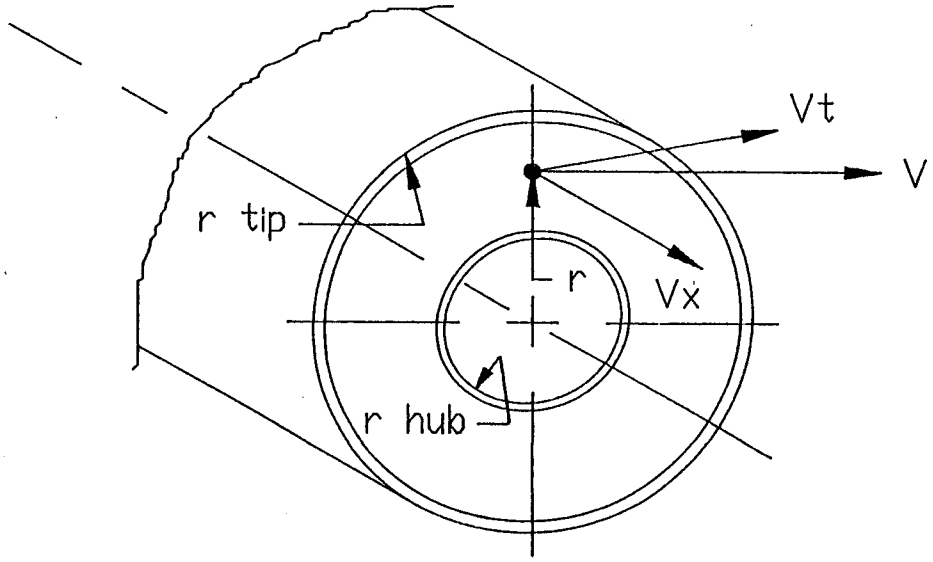


IPPFLOWI

IP7_003265

SWIRL NUMBER

- MEASURE OF JET TANGENTIAL TO AXIAL MOMENTUM
- DETERMINES SIZE OF COMBUSTION INTERNAL RECIRCULATION ZONE



IPP.SN

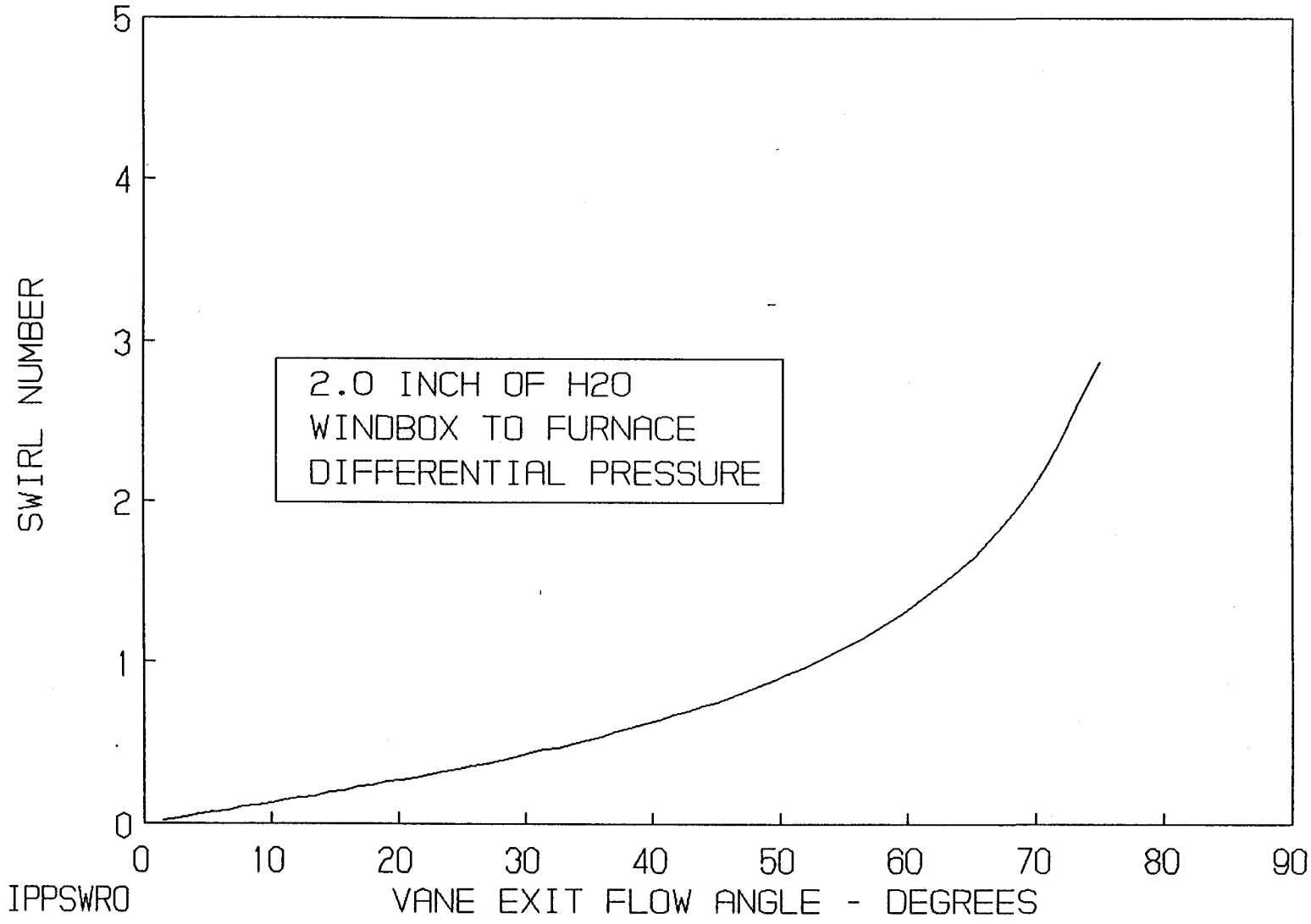
$$\text{Local Swirl No.} = \frac{rV_t}{V_x\, r_{tip}}$$

$$\text{Integrated Swirl No.} = \frac{\int_{r_{hub}}^{r_{tip}} rV_t \;(\rho V_x\, 2\pi r)\,dr}{\int_{r_{hub}}^{r^{tip}} V_x\;(\rho V_x\, 2\pi r)\,dr}$$

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN

SWIRL NUMBER

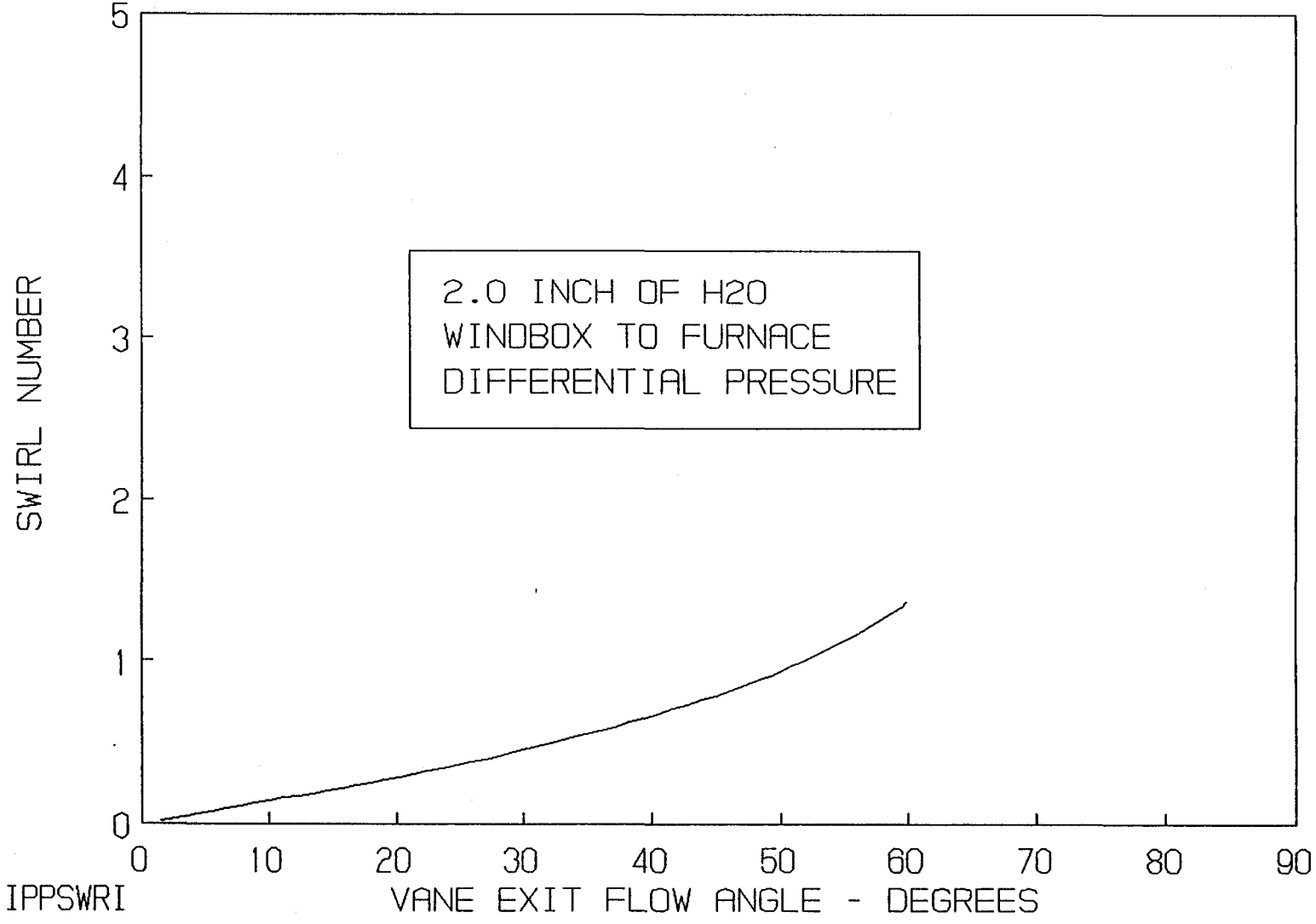


IP7_003267

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

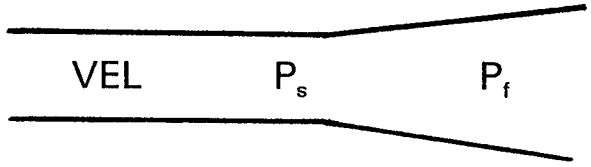
INNER AIR REGISTER - EXISTING DESIGN

SWIRL NUMBER



RECIRCULATION PARAMETER

- MEASURE OF AXIAL MOMENTUM TO OVERCOME LOCAL STATIC PRESSURE TO FURNACE PRESSURE RISE
- POTENTIAL FOR RECIRCULATION EXISTS WHEN THE PARAMETER IS A NEGATIVE VALUE



RECIRCULATION PARAMETER = [(AXIAL MOMENTUM / UNIT AREA) - PRESSURE RISE]

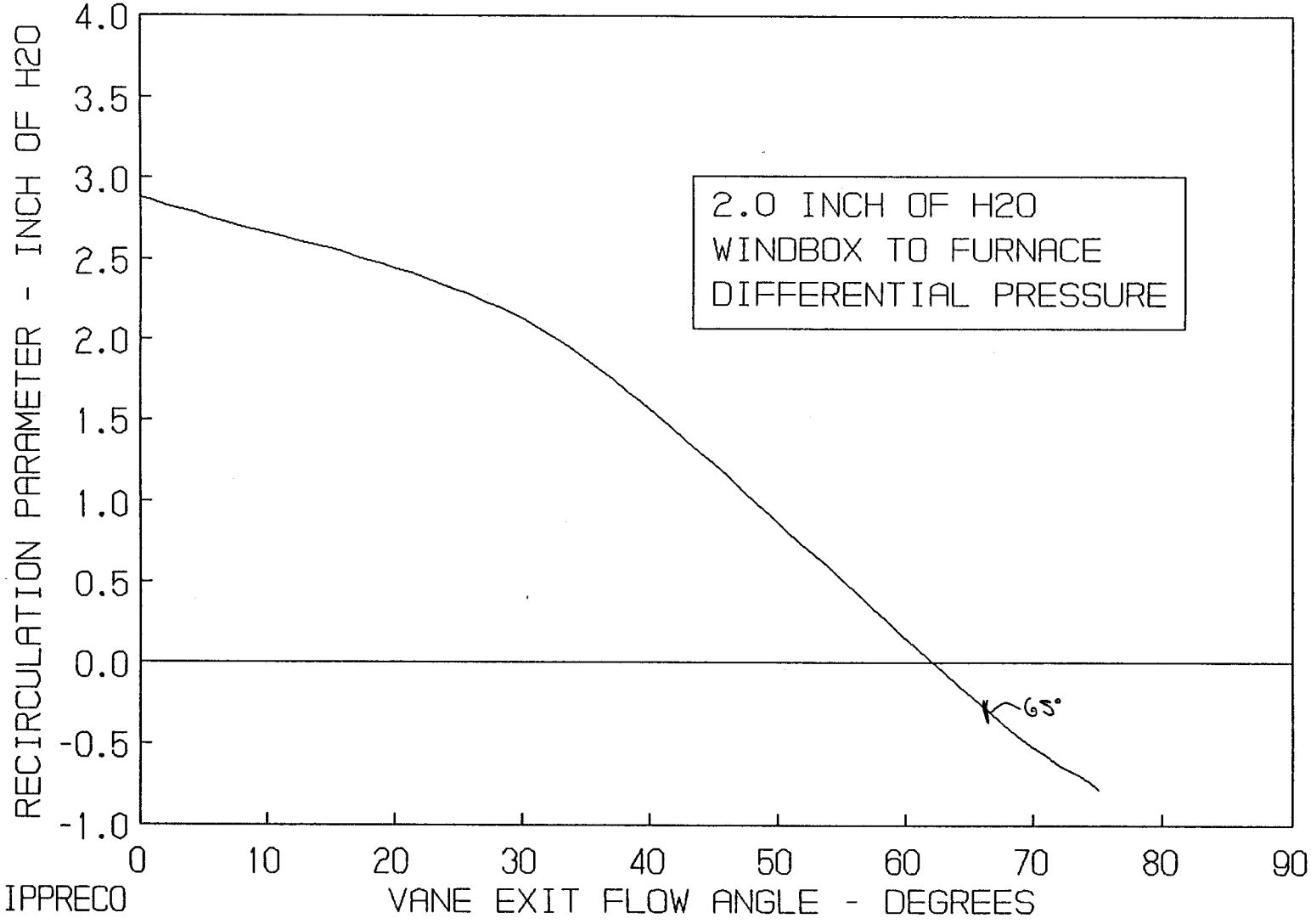
$$\text{RECIRCULATION PARAMETER} = [(\rho V^2 / g_c) - (P_f - P_s)]$$

IPP.RP

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN

RECIRCULATION PARAMETER



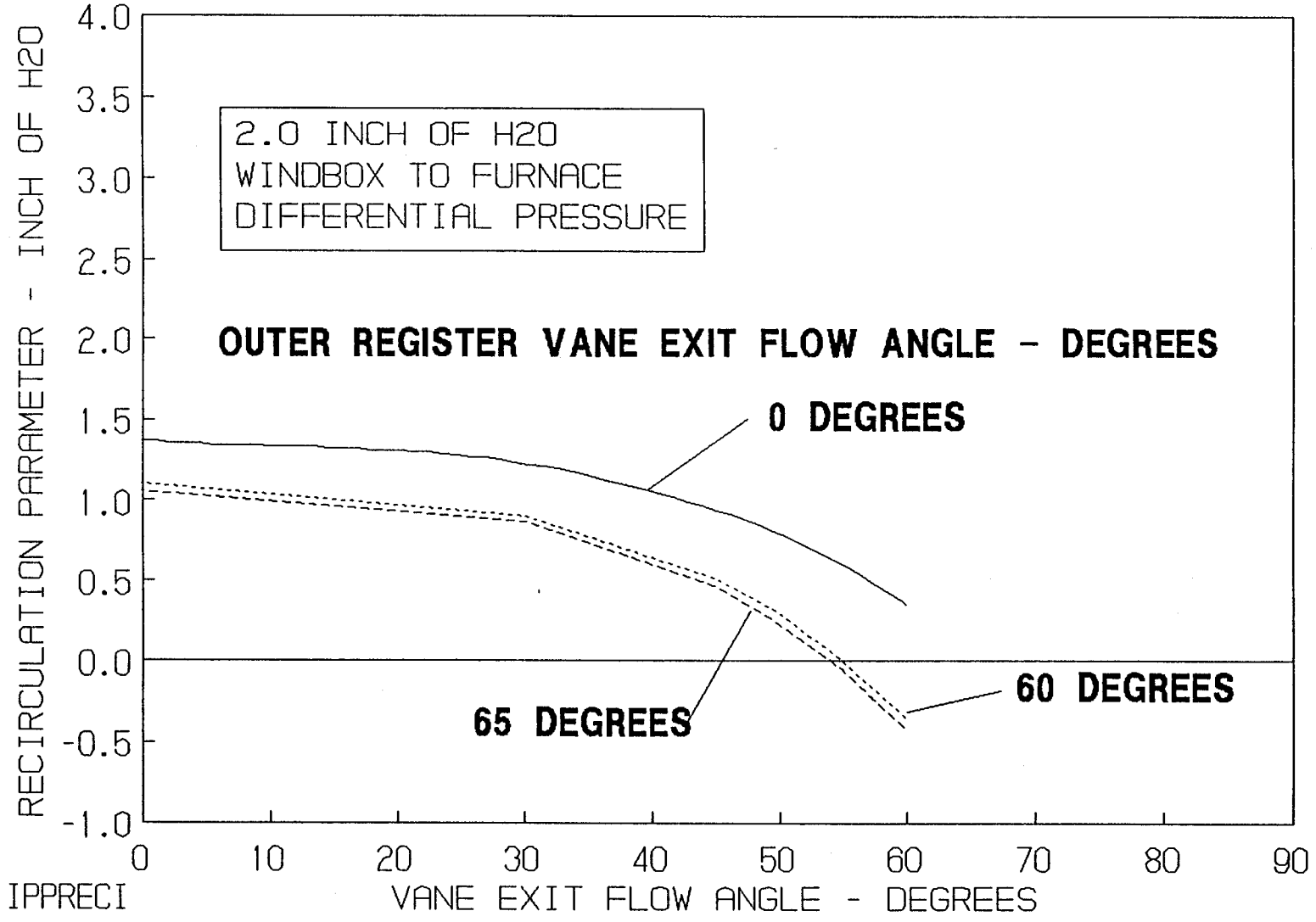
IPPRECO

IP7_003270

1 x

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

INNER AIR REGISTER - EXISTING DESIGN
RECIRCULATION PARAMETER



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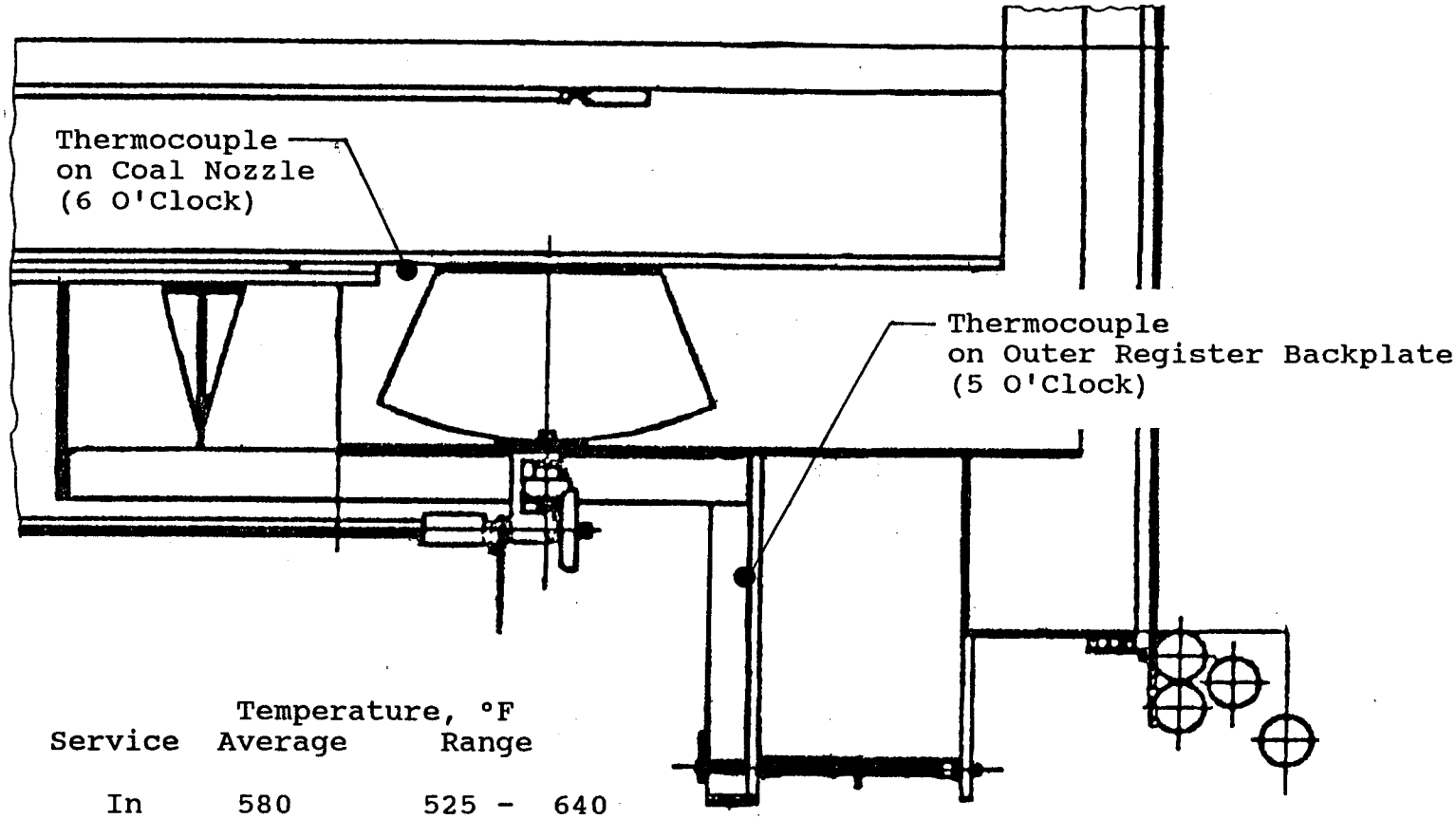
STRUCTURAL ANALYSIS

IPP.SA

MEASURED TEMPERATURES AT FULL LOAD
(AUGUST 30, 1991)



	Service	Temperature, °F Average	Range	
Coal Nozzle	In	580	525 - 640	
	Out	980	830 - 1200	
Outer Register (Back Side)	In	1000	850 - 1220	
	Out	1175	980 - 1285	(1450°F MAX)

INTERMOUNTAIN POWER PROJECT
HEAT TRANSFER ANALYSIS

IN SERVICE

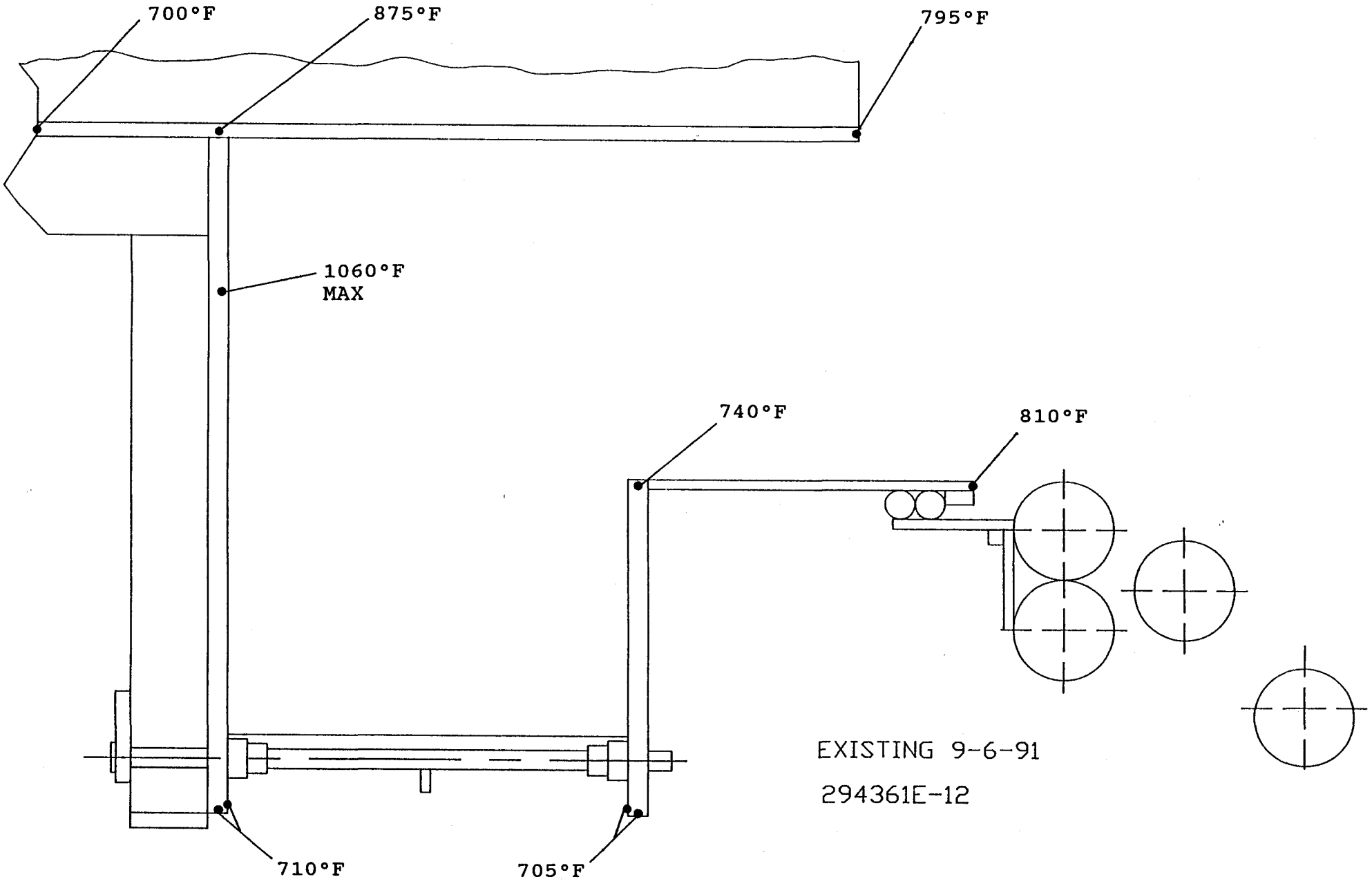
- o CONVECTIVE COOLING FROM 100 PERCENT LOAD REGISTER AIRFLOW
- o FLAME RADIATION PRIMARILY ON BACK WALL
- o BACK PLATE TEMPERATURE: 1,050°F (ANALYSIS) VS. 1,000°F AVG (THERMOCOUPLE)

OUT OF SERVICE

- o CONVECTIVE COOLING TO 20 PERCENT AIRFLOW
- o RADIATION LOAD SAME AS IN SERVICE FOR WORST CASE ANALYSIS
- o ACTUAL RADIATION IS LESS WITH BURNER FLAME OUT
- o PREDICTED BACK PLATE TEMPERATURE HIGHER THAN MEASURED

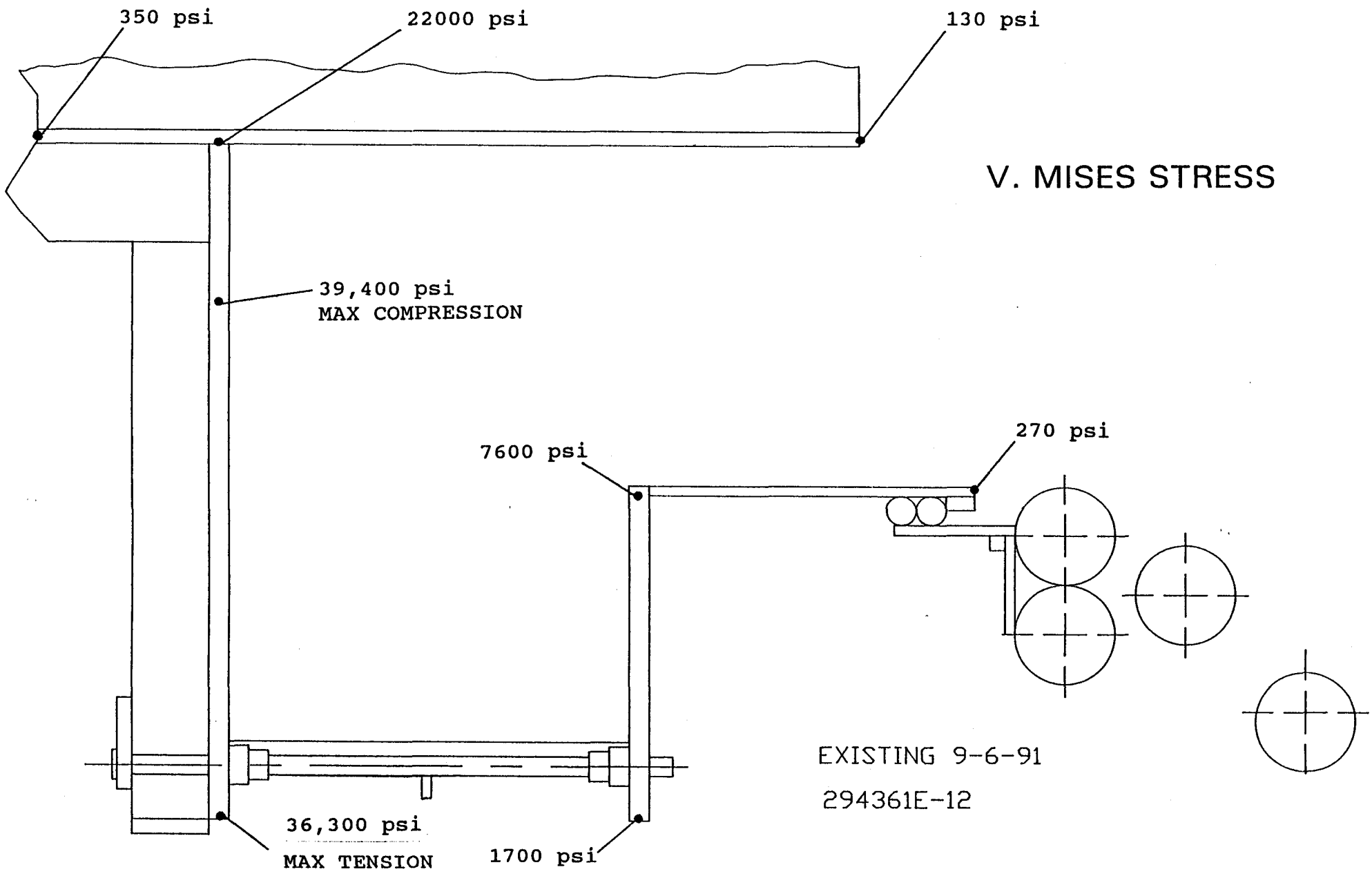
IPPHTA

INTERMOUNTAIN POWER PROJECT
EXISTING DESIGN : IN SERVICE
HEAT TRANSFER ANALYSIS



IP7_003275

INTERMOUNTAIN POWER PROJECT
EXISTING DESIGN : IN SERVICE
STRESS ANALYSIS



IP7_003276

SUMMARY

EXISTING DESIGN (REF. 294361-12)
IN SERVICE

BACK PLATE

- o HOT SPOT ON BACK PLATE OUTBOARD OF INNER SLEEVE WITHIN RANGE OF MEASURED TEMPERATURES
- o HIGH RADIAL TEMPERATURE GRADIENT CAUSES HIGH TANGENTIAL STRESS GRADIENT
- o SEPARATION FROM SLEEVE PREDICTED WITH SUBSEQUENT CONING/BUCKLING

INNER SLEEVE

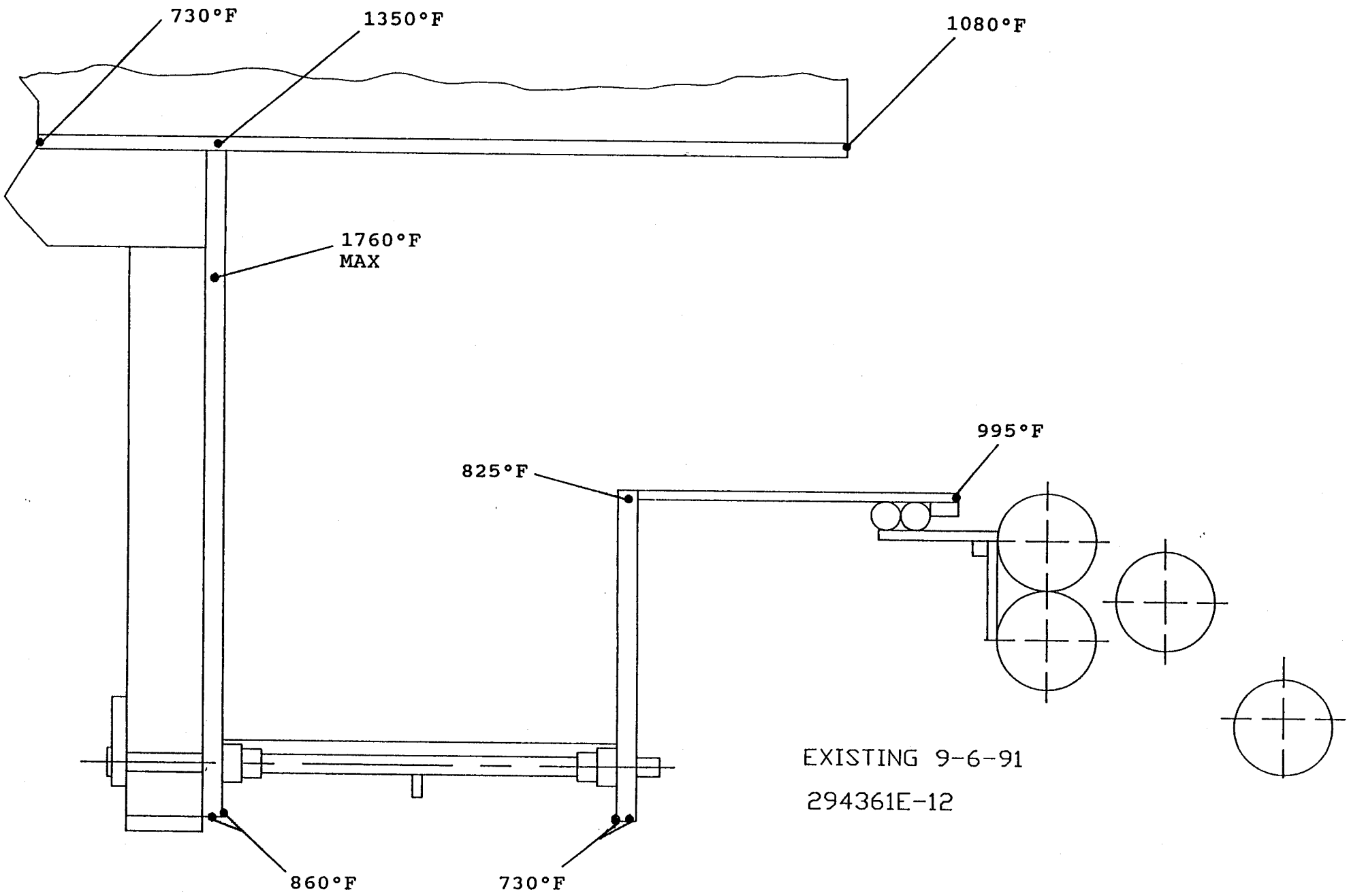
- o LOW TEMPERATURE AND STRESSES EXCEPT FOR LOCAL STRESS CONCENTRATION AT BACK PLATE ATTACHMENT
- o TEMPERATURE/STRESS RELIEF WILL OCCUR FOLLOWING SEPARATION OF BACK PLATE

FRONT PLATE & THROAT SLEEVE

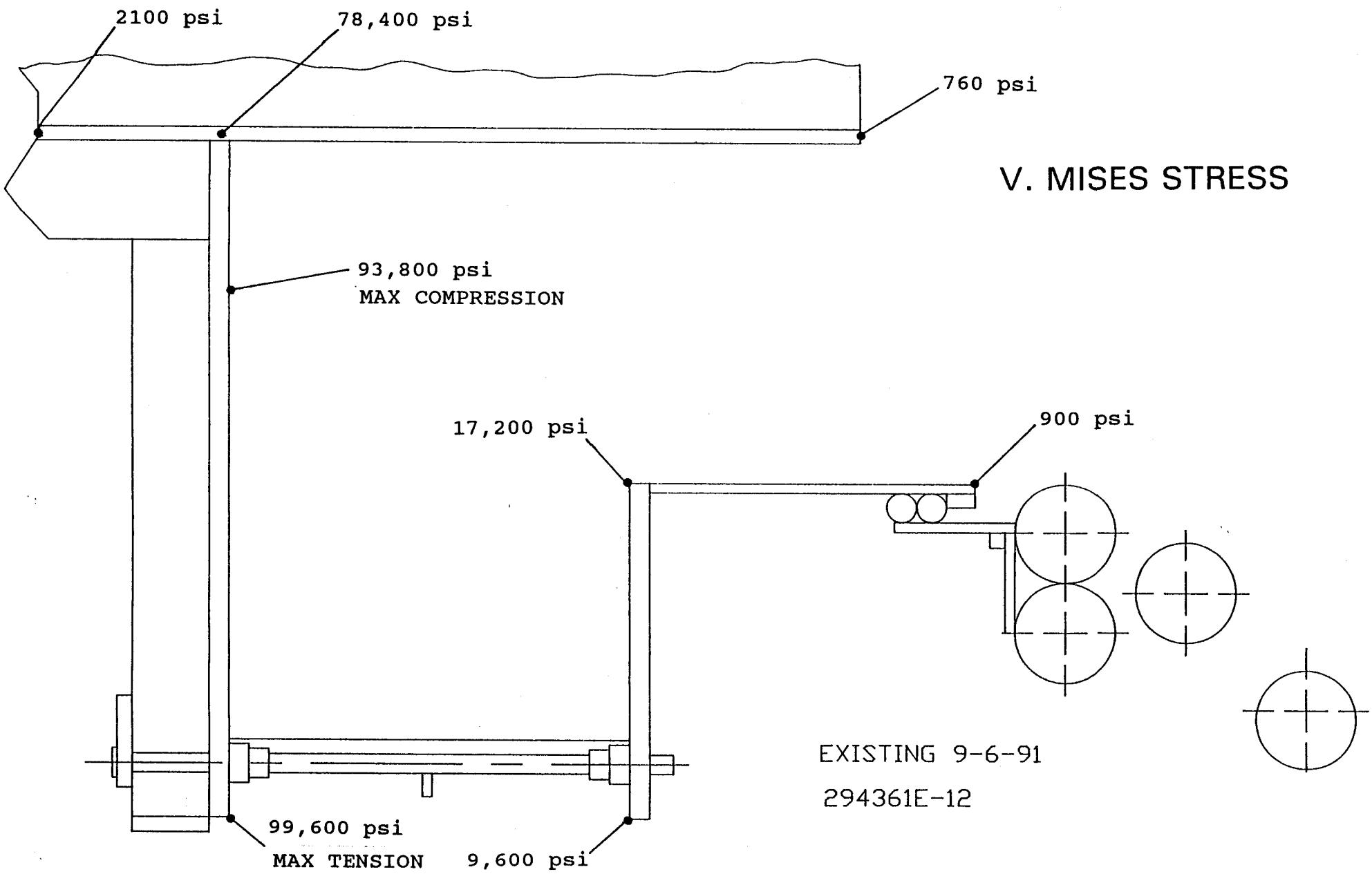
- o LOW TEMPERATURE AND STRESSES EXCEPT FOR LOCAL STRESS CONCENTRATION AT JOINT
- o PREDICTED PEAK STRESS AT JOINT WITHIN ALLOWABLE LIMITS

IPPSUM1

INTERMOUNTAIN POWER PROJECT
EXISTING DESIGN : OUT OF SERVICE
HEAT TRANSFER ANALYSIS



INTERMOUNTAIN POWER PROJECT
EXISTING DESIGN : OUT OF SERVICE
STRESS ANALYSIS



SUMMARY

EXISTING DESIGN (REF. 294361-12)
OUT OF SERVICE

BACK PLATE

- o TEMPERATURES/STRESSES AGGRAVATED BY REDUCED COOLING AIR FLOW
- o MORE SEVERE SEPARATION AND CONING/BUCKLING

INNER SLEEVE

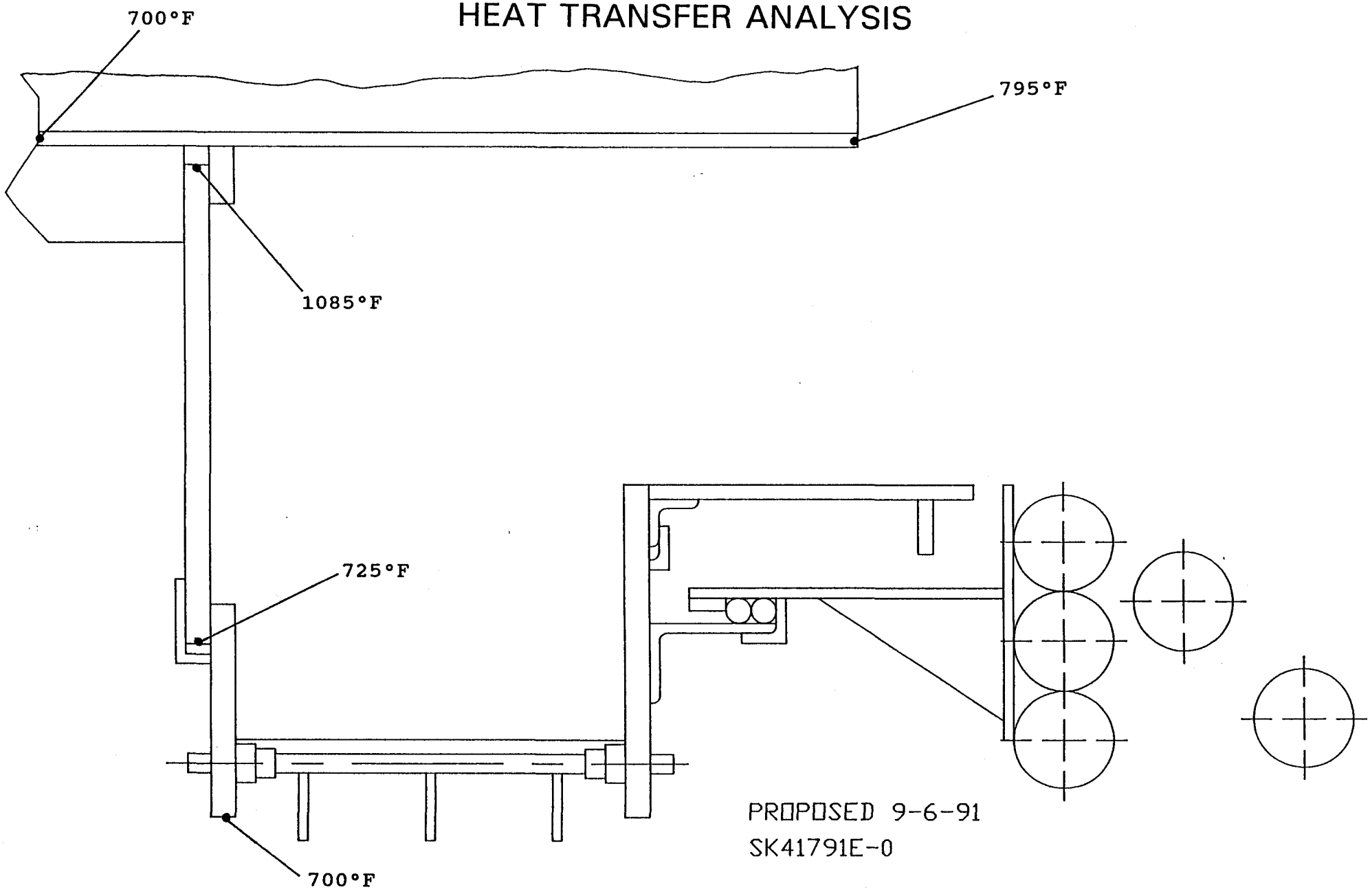
- o MODERATE TEMPERATURES BUT STRESSES REMAIN LOW EXCEPT FOR LOCAL CONCENTRATION AT BACK PLATE ATTACHMENT
- o TEMPERATURE/STRESS RELIEF WILL OCCUR FOLLOWING SEPARATION OF BACK PLATE REDUCING LOCAL STRESS BELOW ALLOWABLE LIMITS

FRONT PLATE & THROAT SLEEVE

- o MODERATE TEMPERATURES AND STRESSES EXCEPT FOR LOCAL STRESS CONCENTRATION AT JOINT
- o PREDICTED PEAK STRESS AT JOINT APPROACHING ALLOWABLE LIMIT
- o ASSUMING SOME RECIRCULATION AND HIGHER TEMPERATURE FOR THE THROAT SLEEVE, THE STRESS WILL BE OVER THE ALLOWABLE WITH EXPECTED JOINT SEPARATION

IPPSUM2

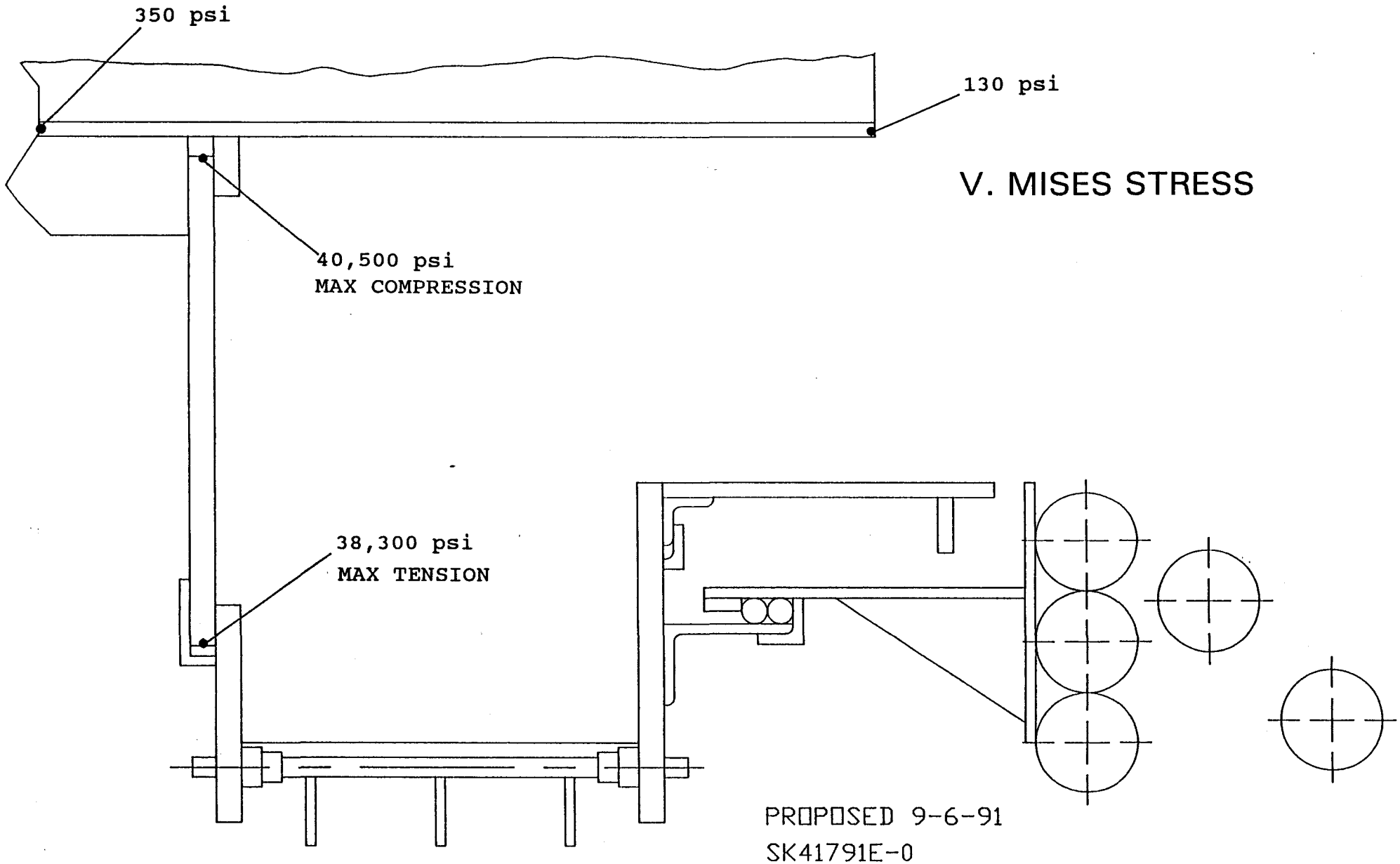
INTERMOUNTAIN POWER PROJECT
PROPOSED DESIGN : IN SERVICE
HEAT TRANSFER ANALYSIS



PROPOSED 9-6-91
SK41791E-0

IP7_003281

INTERMOUNTAIN POWER PROJECT
PROPOSED DESIGN : IN SERVICE
STRESS ANALYSIS



SUMMARY
PROPOSED DESIGN (REF. SK41791E-0)
IN SERVICE

BACK PLATE

- o GENERALLY SIMILAR BACK PLATE WARPING RESULTS AS IN EXISTING DESIGN
- o SLIGHTLY HIGHER TEMPERATURES DUE TO GAP AT INNER SLEEVE
- o HIGHER RADIAL TEMPERATURE GRADIENT CAUSES HIGHER TANGENTIAL STRESS GRADIENT
- o CONING/BUCKLING PREDICTED SIMILAR TO EXISTING DESIGN

INNER SLEEVE

- o LOW TEMPERATURES AND STRESSES - NO LOCAL CONCENTRATIONS

FRONT PLATE & THROAT SLEEVE

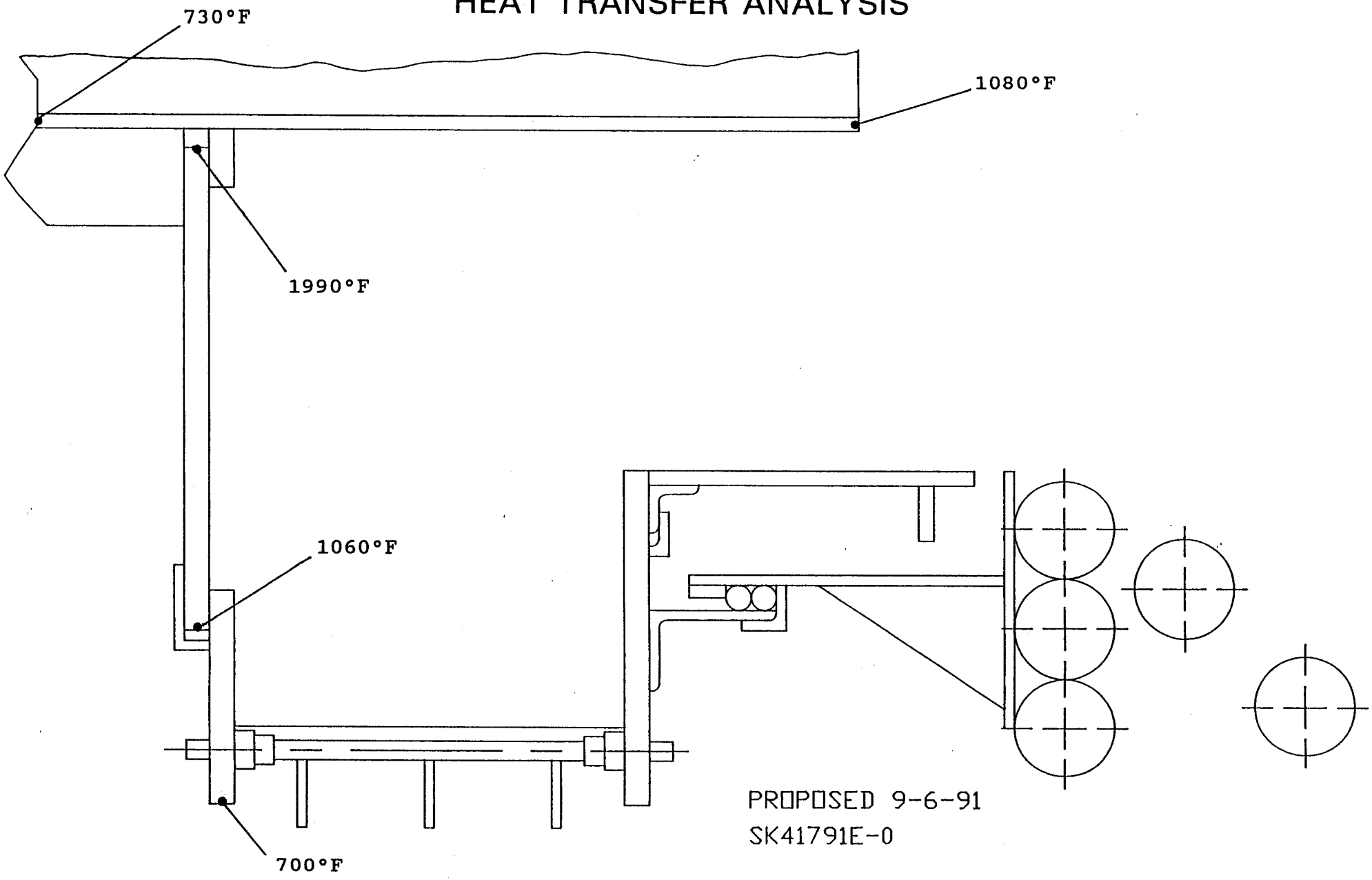
- o ANALYSIS NOT PERFORMED - LOW TEMPERATURES/STRESSES EXPECTED THROUGHOUT

THROAT SLEEVE

- o ANALYSIS NOT PERFORMED - STRESS IN FREE CYLINDER WILL REMAIN LOW REGARDLESS OF TEMPERATURE LEVEL

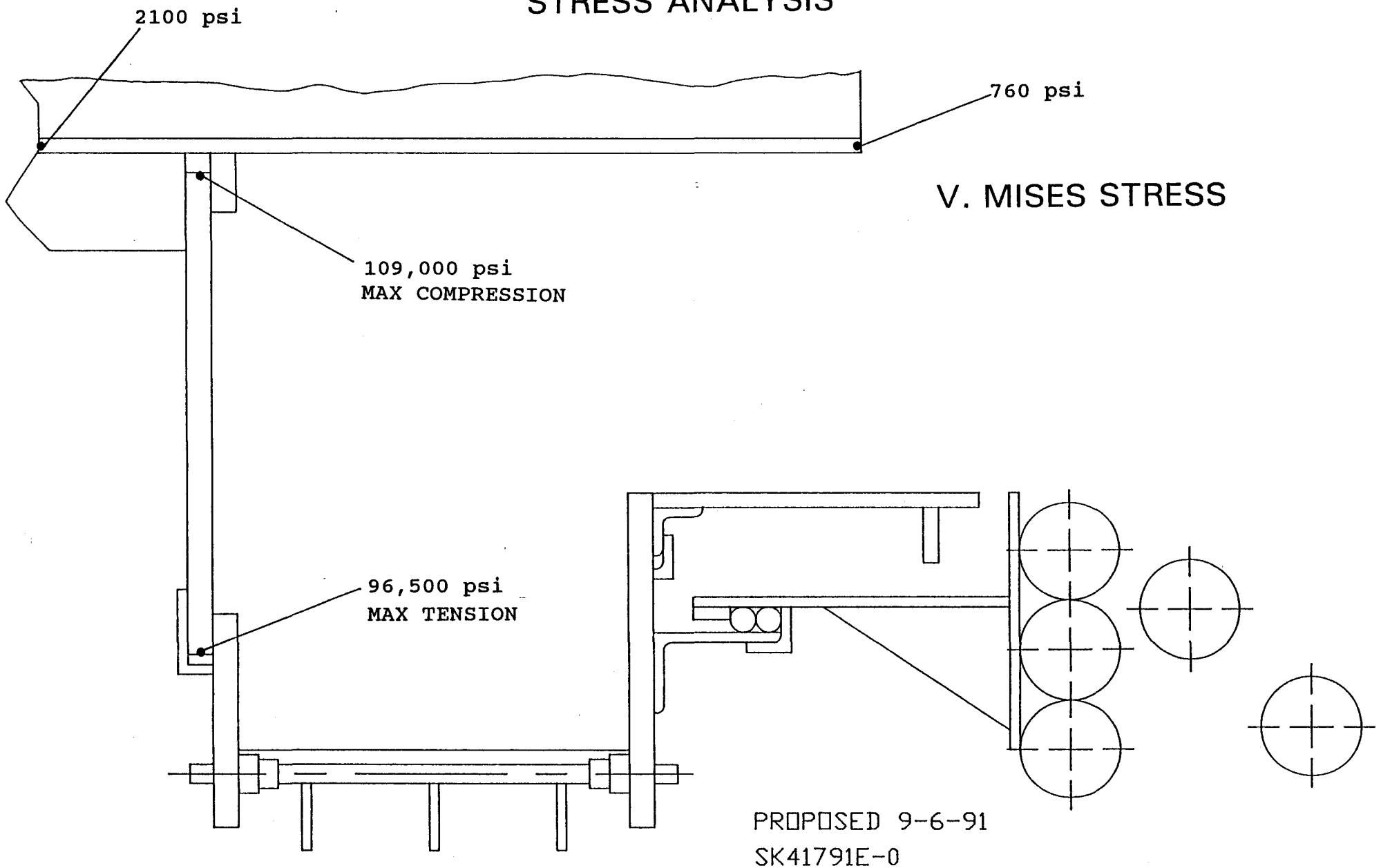
IPPSUM3

INTERMOUNTAIN POWER PROJECT
PROPOSED DESIGN : OUT OF SERVICE
HEAT TRANSFER ANALYSIS



PROPOSED 9-6-91
SK41791E-0

INTERMOUNTAIN POWER PROJECT
PROPOSED DESIGN : OUT OF SERVICE
STRESS ANALYSIS



SUMMARY
PROPOSED DESIGN (REF. SK41791E-0)
OUT OF SERVICE

BACK PLATE & INNER SLEEVE

- GENERALLY SIMILAR RESULTS TO "IN SERVICE", BUT HIGHER STRESSES

FRONT PLATE & THROAT SLEEVE

- ANALYSIS NOT PERFORMED - SIMILAR LOW STRESS RESULTS AS "IN SERVICE"

IPPSUM4

INTERMOUNTAIN POWER PROJECT
CONCLUSION AND RECOMMENDATIONS

BACK PLATE

- EXISTING DESIGN SEPARATION AND BUCKLING CAUSED BY HIGH TANGENTIAL STRESS GRADIENT
- PROPOSED DESIGN DOES NOT RELIEVE STRESS GRADIENT, SO SIMILAR SEPARATION AND BUCKLING ARE EXPECTED
- IT IS RECOMMENDED THAT PROPOSED SLIP FIT PLATE BE DIVIDED INTO SEPARATE PANELS TO ELIMINATE TANGENTIAL STRESS GRADIENT
- SAME MATERIAL AND THICKNESS AS EXISTING DESIGN IS THEREFORE ADEQUATE

INNER SLEEVE & THROAT SLEEVE

- ACT AS FREE CYLINDERS WHEN SEPARATED FROM PLATES RESULTING IN LOW STRESSES REGARDLESS OF TEMPERATURE
- SAME MATERIAL AND THICKNESS AS EXISTING DESIGNS ARE THEREFORE ADEQUATE

FRONT PLATE

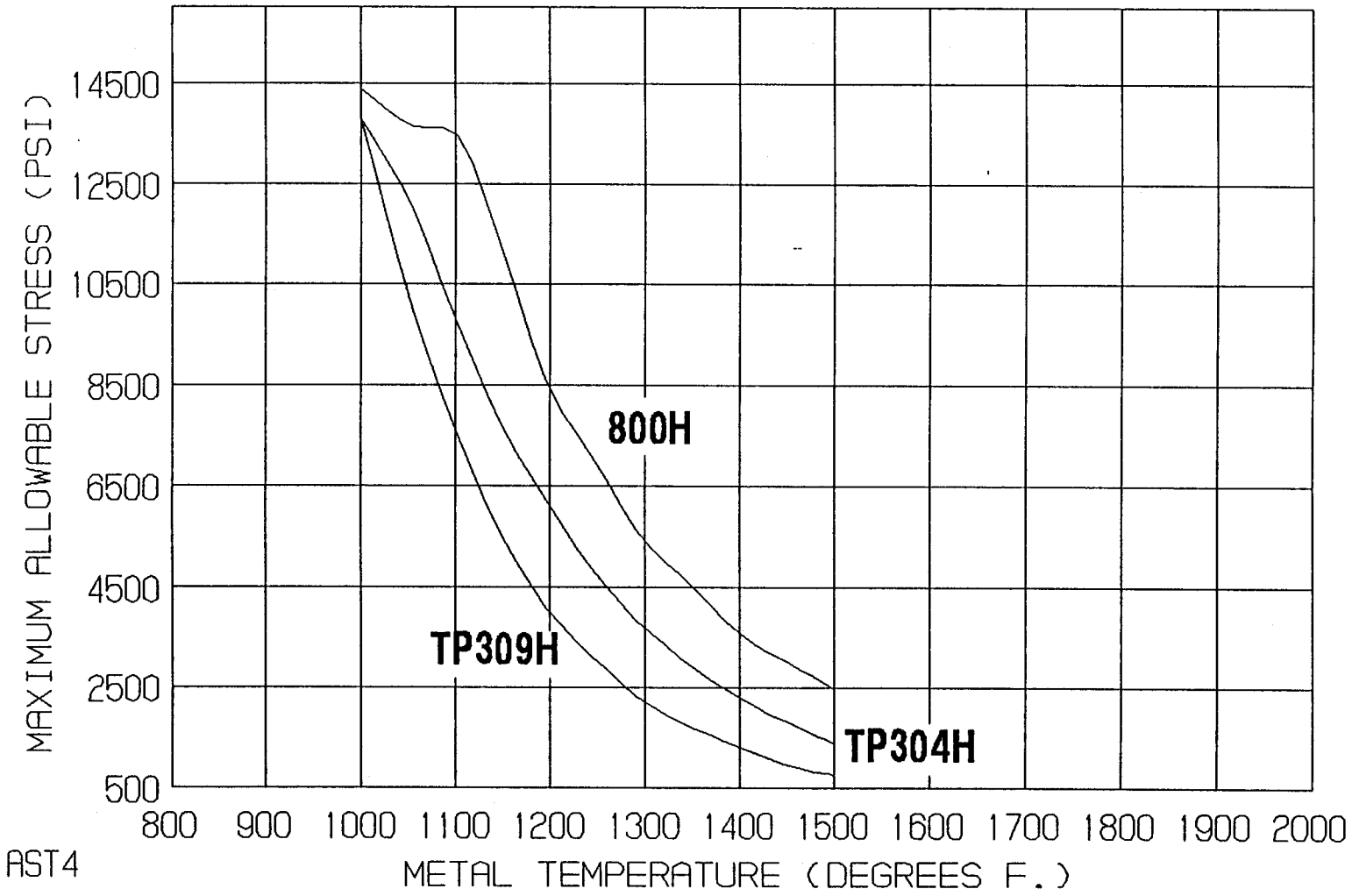
- EXISTING DESIGN STRESS CONCENTRATION AT JOINT WITH THROAT SLEEVE ELIMINATED BY SLIP FIT PROPOSED DESIGN.
- SAME MATERIAL AND THICKNESS AS EXISTING DESIGN IS THEREFORE ADEQUATE

IPPCON

MATERIAL PROPERTIES

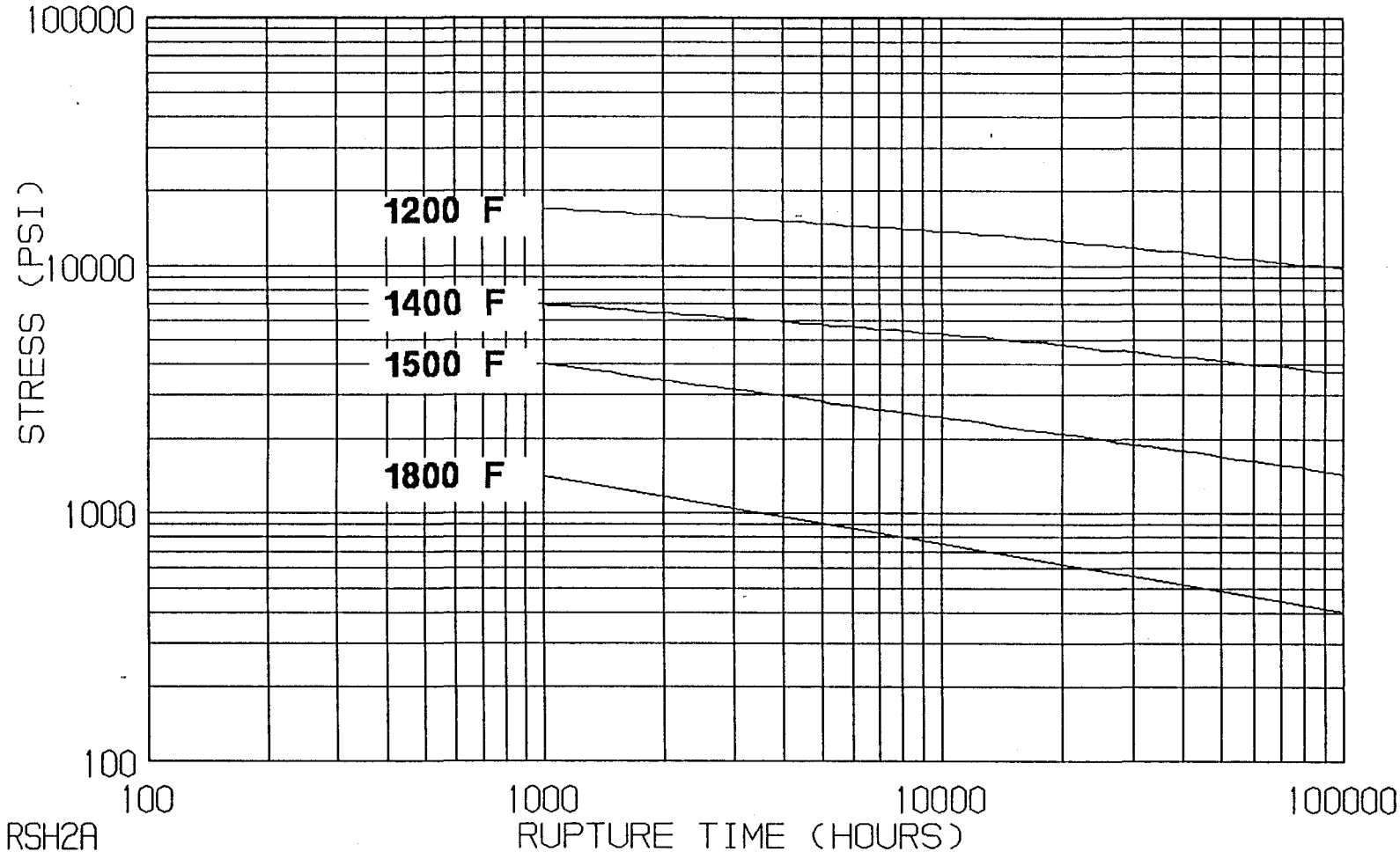
IPP.MP

ALLOWABLE STRESS VS. TEMPERATURE

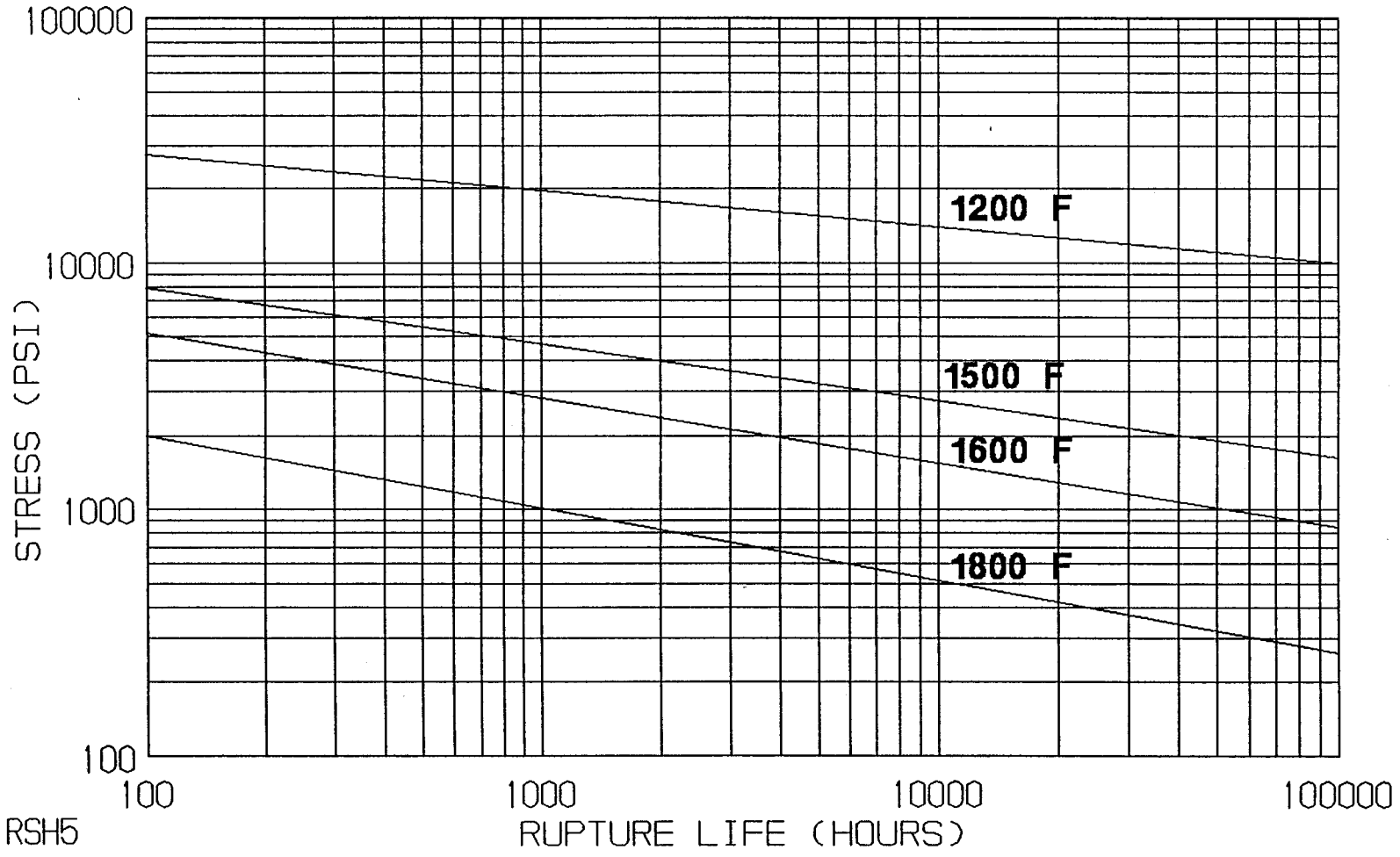


AST4

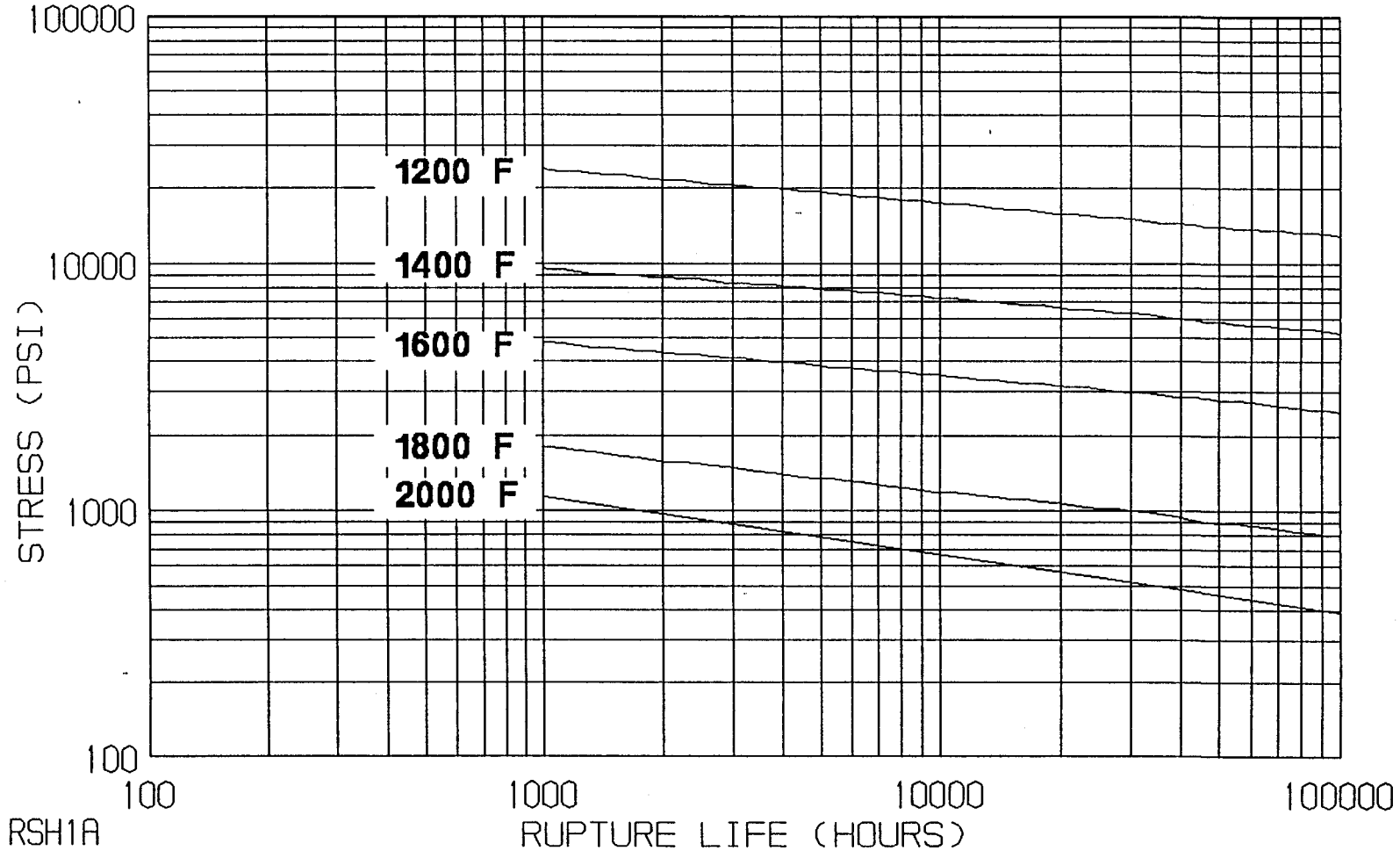
RUPTURE STRENGTH OF TP304



RUPTURE STRENGTH OF TP309



RUPTURE STRENGTH OF INCOLOY 800HT



INTERMOUNTAIN POWER PROJECT

- o BURNER MECHANIAL DESIGN OPTIMIZATION
- o COAL FLAME STABILIZER
- o NOx EMISSIONS

IPP.CON